

# Right Upper Lobe Sleeve Resection

Steven J. Mentzer

The first plastic-reconstructive procedures of the airway were performed after traumatic injury and tuberculous bronchostenosis.<sup>1</sup> The success of these early procedures led to the first bronchial sleeve resection for adenoma<sup>2</sup> and carcinoma,<sup>3,4</sup> during 1951 through 1952. Sleeve lobectomy was considered an alternative to pneumonectomy in patients with bronchogenic carcinoma because it preserved lung tissue and improved the quality of postoperative survival.

Recent long-term studies of patients with lung carcinoma suggest that the results of sleeve lobectomy are comparable to the expected survival after standard lobectomy or pneumonectomy. Weisel et al<sup>5</sup> reported no difference in the actuarial survival of 70 patients undergoing sleeve lobectomy compared with 70 patients undergoing pneumonectomy for stage I or II disease. Firmin et al<sup>6</sup> showed that sleeve resection of squamous cell carcinoma of the upper lobe, in the absence of nodal metastases, produced a 5-year survival of 71%. In a series of 52 patients with T2N0 or T3N0 squamous cell carcinoma, sleeve lobectomy produced 5- and 10-year survival rates of 59% and 47%.<sup>7</sup> In a series of 101 sleeve lobectomies for stage I through stage III disease, Rush-Presbyterian-St. Luke's Medical Center reported overall 5-year survival rates of 30% to 33%.<sup>8,9</sup>

The right upper lobectomy is the most common sleeve resection. Surveys in Japan have shown that upper-lobe sleeve resections represent 87% of all sleeve lobectomies performed.<sup>10</sup> Because of the relative length of the bronchus intermedius and the favorable arterial anatomy, right upper-sleeve lobectomies are performed more than twice as frequently as left upper-sleeve lobectomies.<sup>10</sup> A review of several published patient series support these findings with 76% of the sleeve lobectomies being performed for cancers of the right upper lobe.<sup>6,7,11,12</sup>

## Indications

The contemporary indication for sleeve resection of the right upper lobe is a localized tumor at the orifice of the right upper lobe (Figure 1). The tumor can be either benign or malignant. We consider any patient a candidate for a sleeve lobectomy if they meet two criteria: (1) the surgical resection margins are free of tumor; and (2) there are no nodal or distant metastases. For patients with carcinoid tumors, the risk of nodal disease is

small.<sup>13</sup> The predominant clinical concern is the potential extraluminal extension of these tumors. Commonly referred to as iceberg tumors, the carcinoid tumor can extend far beyond the tumor visible by fiberoptic bronchoscopy. The feasibility of sleeve resection in these cases is necessarily assessed at the time of thoracotomy. For patients with bronchogenic carcinoma, an initial metastatic evaluation involves a chest computed tomographic (CT) scan (including liver and adrenal glands), head CT scan, and bone scan. In the absence of extrathoracic metastatic disease, the patients should be staged with bronchoscopy and mediastinoscopy.

## Surgical Staging

Fiberoptic bronchoscopy and cervical mediastinoscopy can be performed as an outpatient procedure. Fiberoptic bronchoscopy provides an opportunity to directly examine the extent of the tumor. We routinely perform

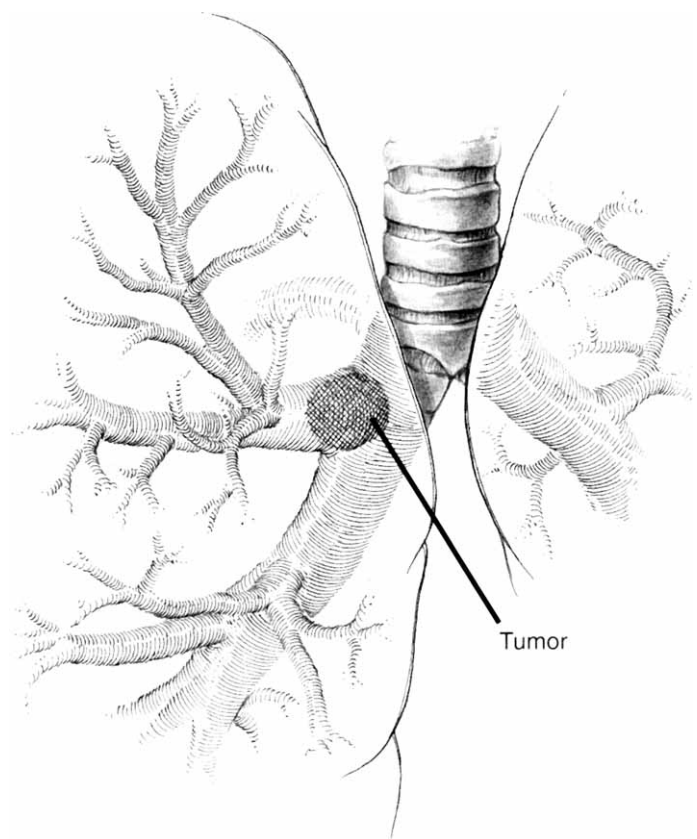


Fig 1. The indication for sleeve resection of the right upper lobe, a localized tumor at the orifice of the right upper lobe.

bronchial biopsies of the proximal and distal mucosa (Figure II). The primary reason for obtaining these biopsy specimens is that many patients will have dysplastic bronchial mucosa from smoking or chronic infection. Permanent histopathology is far superior to a frozen section evaluation of the mucosa at the time of surgical resection. In patients with obstructing lesions, bronchoscopy also provides an opportunity to obtain microbiological brush cultures of the distal airways. Appropriate antimicrobial therapy can be instituted before definitive resection.

Cervical mediastinoscopy can provide a thorough assessment of the most important areas of potential nodal metastases (Figure III). A right upper tumor will most frequently metastasize to the right tracheobronchial angle lymph nodes.<sup>14</sup> In the original American Thoracic Society lymph node map, these tracheobronchial angle lymph nodes were designated level 10R.<sup>15</sup> The recently published staging system includes the right

tracheobronchial angle lymph nodes in the 4R level.<sup>16,17</sup> Regardless of the specific designation, the tracheobronchial angle lymph nodes can be readily biopsied by cervical mediastinoscopy. At our institution, the presence of right tracheobronchial angle lymph node metastases would be an indication for a neoadjuvant chemotherapy trial. The potential for further surgery would be re-evaluated at the conclusion of neoadjuvant therapy.

The subcarinal (level 7) lymph nodes are more frequently considered a primary site of lower and middle lobe metastases.<sup>18</sup> Proximal right upper-lobe tumors, however, rarely present with subcarinal metastatic disease. In a detailed histopathologic study, Nohl-Oser<sup>14</sup> noted that only 1 of 14 patients with mediastinal metastatic disease from a right upper-lobe cancer had selective subcarinal involvement. Cervical mediastinoscopy provides access to these lymph nodes on the medial aspect of the right mainstem bronchus.

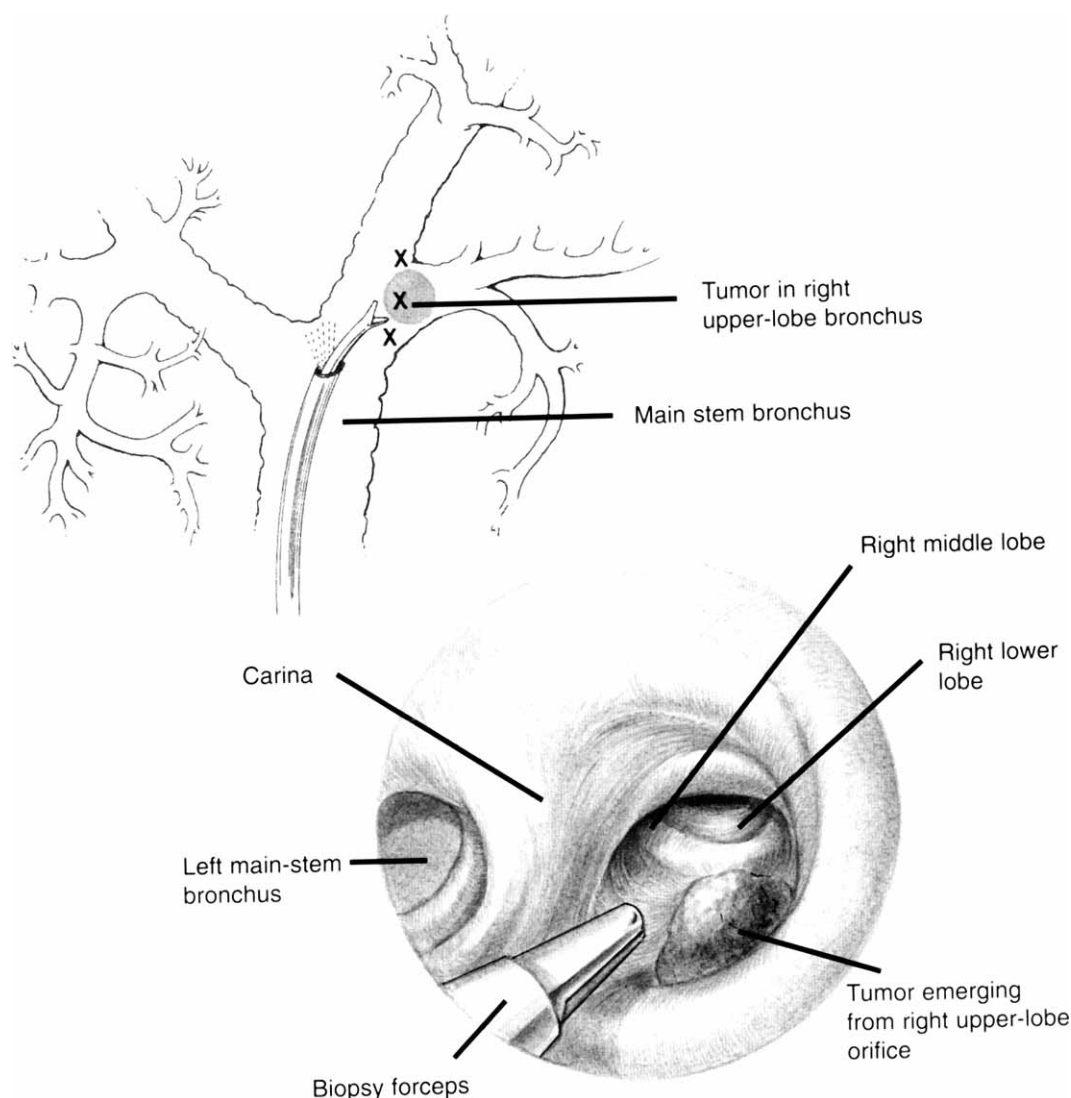


Fig II. A bronchial biopsy of the proximal and distal mucosa. X represents the biopsy site.

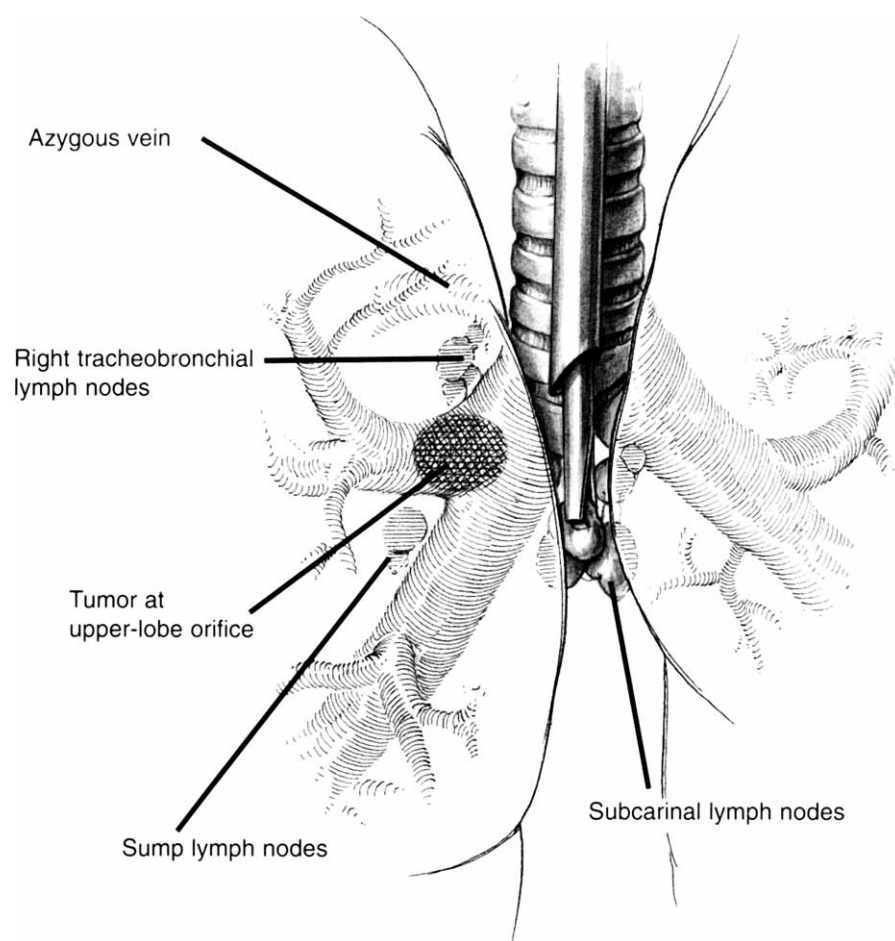


Fig III. Cervical mediastinoscopy.

We routinely biopsy both the superficial and deep subcarinal lymph nodes. The mediastinoscopic dissection is extended along the bronchus intermedius as far as possible. This dissection not only provides more accurate surgical staging, but facilitates the subsequent dissection of both the mainstem bronchus and bronchus intermedius at the time of sleeve resection.

Two additional sites of potential metastases cannot be assessed by mediastinoscopy. The most important of these two areas are the so-called "sump" lymph nodes along the bronchus intermedius and the ongoing pulmonary artery (Figure III). These lymph nodes are of particular interest because they reflect the relative efficacy of sleeve lobectomy and pneumonectomy in

eliminating potential nodal disease. Disease studies have found that these lymph nodes were involved in only 28% of right upper-lobe carcinomas.<sup>14</sup> Although sump node metastases do occur, nodal metastases have not been reported distal to a transverse line drawn at the level of the distal bronchus intermedius. These findings support the use of right upper-sleeve lobectomy if the sump nodes are carefully evaluated. The second site of potential occult-nodal involvement is the azygous node. The azygous node is found lateral to the azygous vein in a minority of patients, but represents a potential site of right upper-lobe metastases.<sup>19,20</sup> Both of these areas should be assessed at the outset of the thoracotomy.

## SURGICAL TECHNIQUE

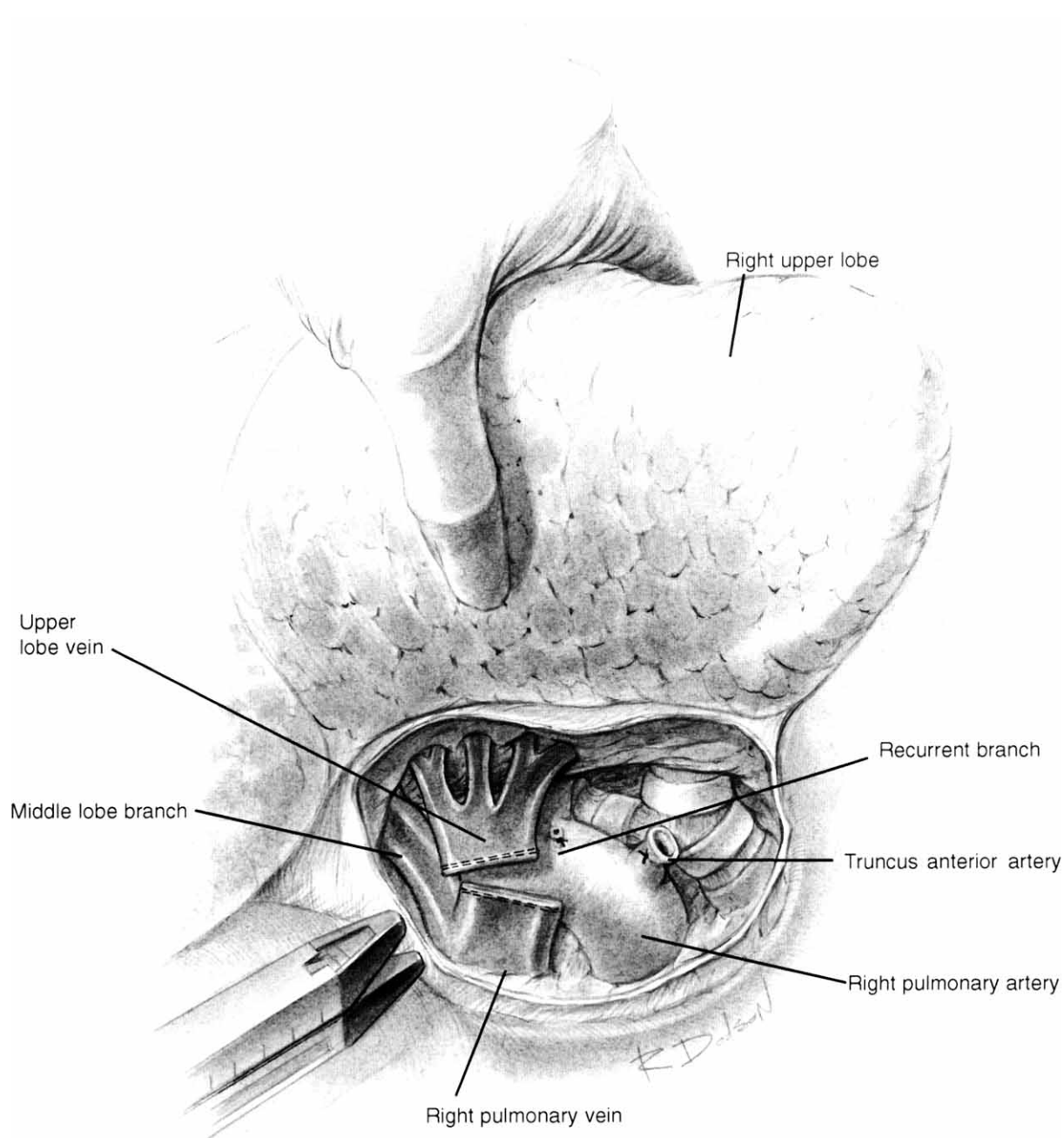
After staging the bronchoscopy and cervical mediastinoscopy, we schedule the potential sleeve lobectomy for the following week. This provides an opportunity to obtain histopathology results on both the mucosal and lymph node biopsies. In addition, finalized bacterial cultures with antibiotic sensitivities can be obtained and the appropriate therapy can be instituted.

All patients undergoing a sleeve lobectomy receive an epidural catheter for intraoperative and postoperative analgesia. After the induction of general endotracheal anesthesia, a left-sided, double-lumen endotracheal tube is placed. Placement of the tube in the left mainstem bronchus is confirmed by fiberoptic bronchoscopy. The patient is placed in left-lateral decubitus position. A posterolateral thoracotomy incision is made and the chest is entered through either the fourth or fifth intercostal space.

When entering the chest, the right hemithorax is carefully examined for evidence of intrathoracic spread. Adequate mediastinoscopic dissection is confirmed by right paratracheal and subcarinal hematomas visible through the mediastinal pleura. The right lower and

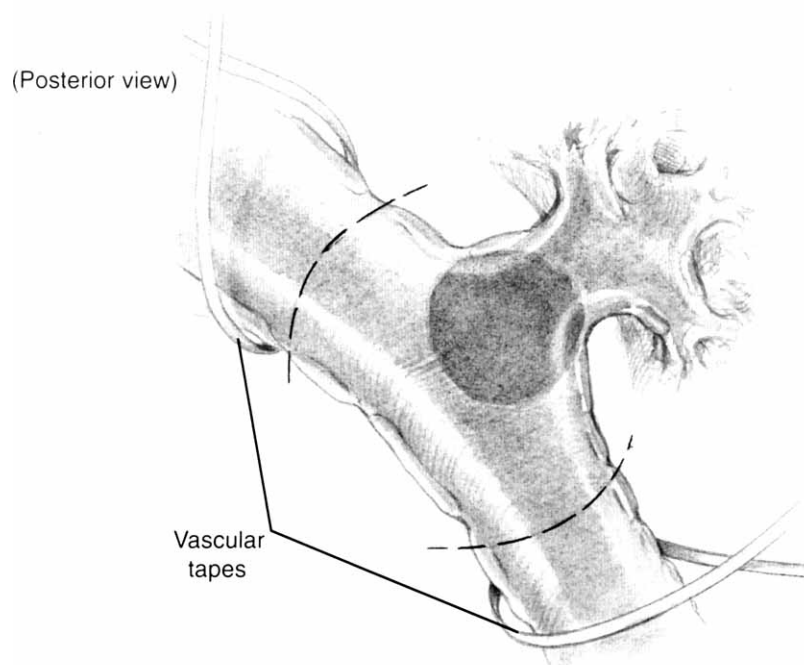
middle lobes are carefully examined for evidence of second primaries or metastatic disease. The mediastinal pleura is circumferentially incised around the right hilum and the inferior pulmonary ligament is mobilized. The right tracheobronchial angle and azygous vein are examined for previously unassessed nodal disease. Similarly, the major fissure is developed and the sump lymph nodes are evaluated. Finally, the posterior hilum is examined for unexpected extension of the tumor into the mainstem bronchus or distal bronchus intermedius.

The proximal main pulmonary artery and superior pulmonary vein are fully dissected. The main pulmonary artery is encircled with vascular tape. The vascular tape facilitates proximal clamping of the pulmonary artery should an angioplastic procedure or vascular sleeve resection be required. Although angioplasty is unusual in right upper-lobe sleeve resections, mobilization of the entire pulmonary artery is required for an adequate airway dissection. In addition, the vascular tape facilitates exposure of the airway with anterior retraction of the ongoing pulmonary artery.



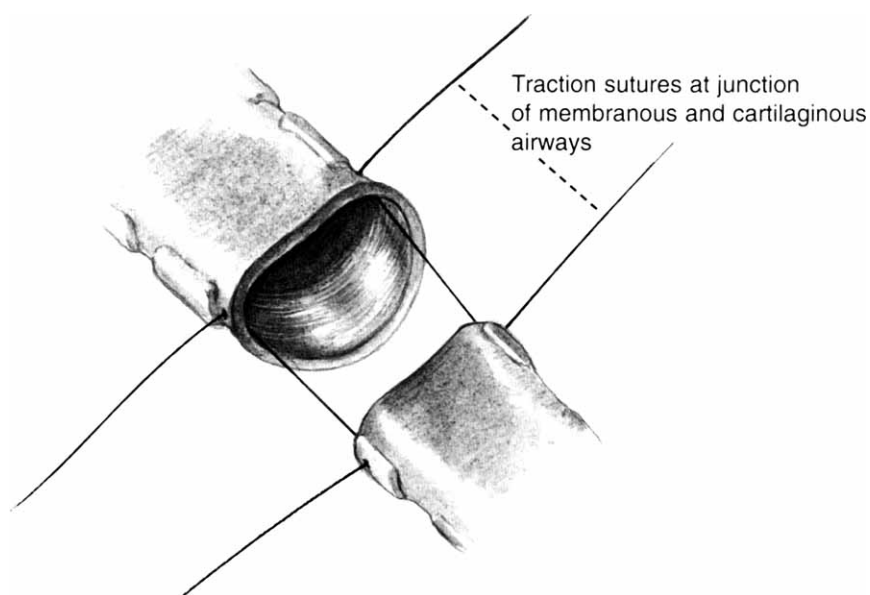
**I** When the hilum is dissected, the truncus anterior artery is divided between silk ties or with a vascular stapler. The vascular stapler we typically use is a 30-mm thoracoscopic stapler that can also be used to transect the superior pulmonary vein. After transection of the proximal artery and vein, the posterior recurrent branch of the pulmonary artery is readily exposed and divided. The pulmonary artery should be fully mobilized to the level of the superior segmental artery.

The division of the posterior recurrent branch of the pulmonary artery facilitates complete mobilization of the right upper-lobe major fissure. Whether sharp dissection, electrocautery, or a stapler is used to complete the fissure, care must be taken to minimize any potential air leaks. Pleural air leaks can entrain oral bacteria and be a source of potentially disastrous infectious complications. The minor fissure is usually completed with a stapler.

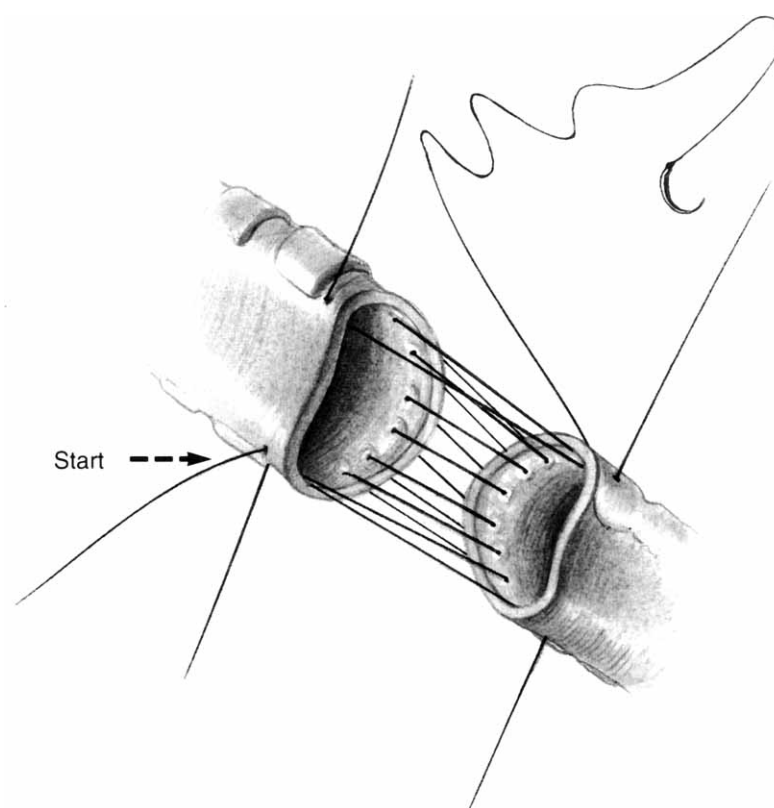


**2** The right upper lobe is fully mobilized before transecting the airway. First, the right mainstem bronchus is mobilized by passing umbilical tape around in the airway (through the space created by the previous mediastinoscopic subcarinal dissection). Similarly, the bronchus intermedius is mobilized and encircled with umbilical tape. The proximal and distal tapes permit a careful inspection of the potential surgical margins before transecting the airway. The relative size mismatch of the airways can also be evaluated.

The bronchus is transected in a plane transverse to the axis of the airway. The perpendicular transection of the airway minimizes the size mismatch and facilitates the subsequent anastomosis. The oblique orientation of the airway cartilage can be misleading. The use of a needle-nose clamp to crush the cartilage in the appropriate orientation may be helpful in a teaching setting. When both the proximal and distal airways have been transected, the specimen is submitted to the pathology laboratory for frozen section evaluation of both the proximal and distal margins. Aerobic and anaerobic cultures are also obtained from the resected lung.



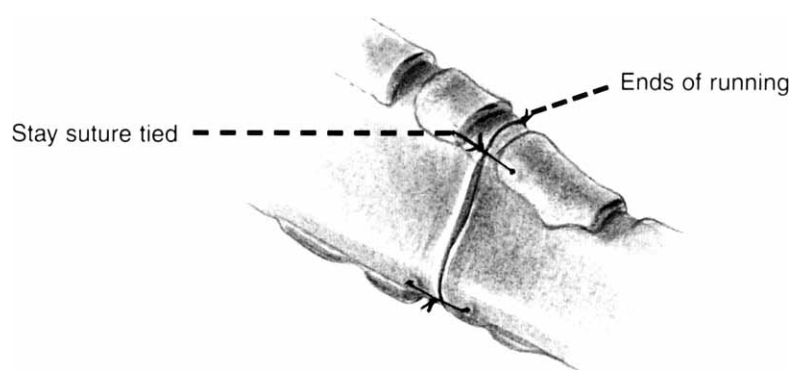
**3** The orientation of the proximal and distal airways can be maintained with traction sutures. Although the orientation is more problematic in other sleeve lobectomies, we routinely place 3-0 monofilament traction sutures at the cartilaginous membranous junction. The sutures are placed in the cartilage to allow rotational traction in the airway and facilitate exposure for the anastomosis.



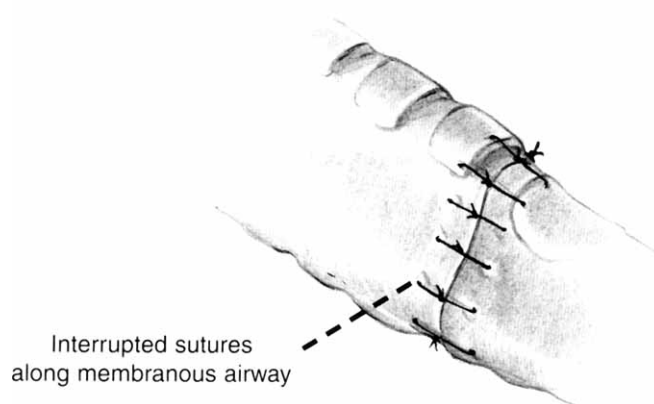
**4** The cartilaginous portion of the anastomosis is constructed using 3-0 monofilament (polypropylene) sutures. Monofilament sutures provide additional strength for the first several months after airway reconstruction. The persistence of these sutures may help minimize the rotational deformation of the airway that can be bronchoscopically observed several years after sleeve resection. In addition, monofilament sutures are more convenient to use with a running technique. Our limited experience with slowly absorbing polydioxanone sutures (PDS; Ethicon, Somerville, NJ) suggests that PDS is not indicated for airway reconstructions in adults. PDS is generally nonreactive; however, when chronic granulation tissue does form, the PDS suture may take years to absorb and this can result in persistent airway granulation tissue.

The advantage of using a running suture on the cartilaginous portion of the anastomosis is that the suture can be placed using an open technique. The medial cartilaginous anastomosis can be sewn with optimal visualization and without the cumbersome untied sutures of an interrupted technique. The running technique also obviates the need for knots on the inside of the airway. The use of absorbable synthetic sutures with knots on the inside of the airway can become a potential problem when dissolving sutures hang into the airway and impede mucociliary clearance.



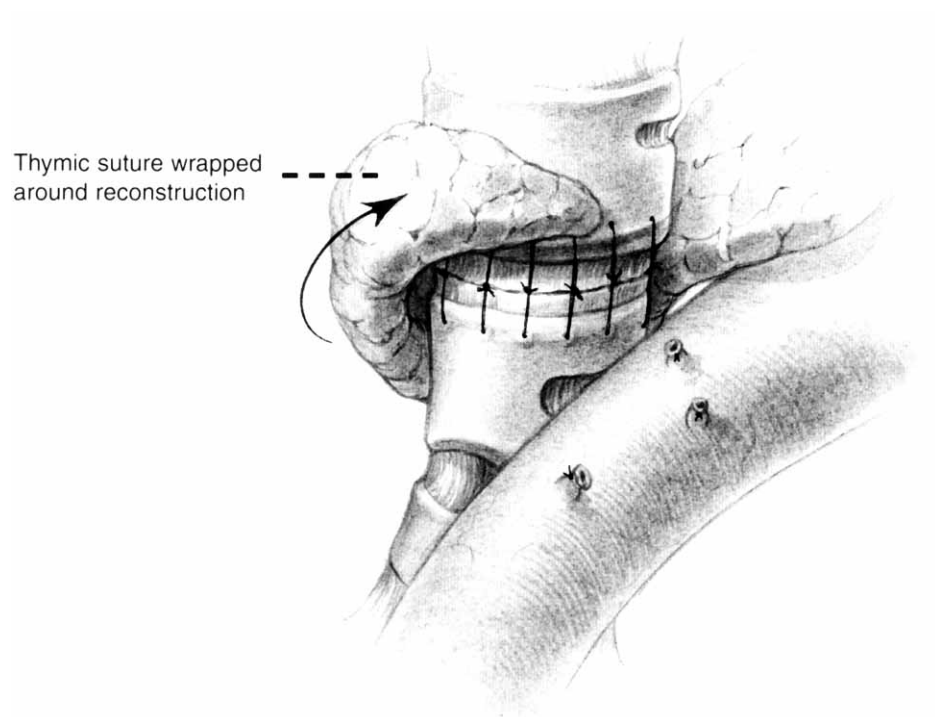


**5** When the running suture has been placed, the traction sutures are used to approximate the main bronchus and the distal bronchus intermedius. The size discrepancy in the proximal and distal airways can be evaluated at this point in the procedure. In the past, we tailored the membranous mainstem bronchus so that a size-matched end-to-end anastomosis could be constructed.<sup>5</sup> Our lung transplant experience with telescoped anastomoses, however, encouraged us to apply this technique to sleeve lobectomies. An informal comparison of these two techniques suggests that they are indistinguishable 3 months after reconstruction. After the two traction sutures have been tied, the knot is buried and the running and traction sutures are tied. The traction sutures are not cut, but used to facilitate exposure of the membranous airway.



**6** The membranous portion of the anastomosis is completed with interrupted braided 3-0 absorbable (Vicryl; Ethicon, Somerville, NJ) sutures. In most cases, the membranous airway requires only two or three sutures. Although it is possible to use a circumferential-running monofilament suture to close the membranous portion of the airway, the differential strength of the membranous and cartilaginous airways risks a tear in the membranous portion when the sutures are tightened.

After completion of the anastomosis, the remaining right lung is ventilated. The anastomosis can be tested for an air leak using saline irrigation. The care taken to prevent an air leak in the major and minor fissures is rewarded by the absence of air bubbles near the bronchial reconstruction. Because the completed major and minor fissures rotate toward the anastomosis with reinflation, the evaluation of the source of the air leak can be ambiguous. The remaining middle and lower lobes should reinflate easily. Intraoperative bronchoscopy can be useful to evaluate the anastomosis and remove any retained secretions.



**7** Although uncomplicated anastomotic healing is the rule, any airway separation or perianastomotic infection can lead to a catastrophic bronchovascular fistula. Normal tissue can be interposed between the bronchial anastomosis and the pulmonary artery to prevent this complication. We typically mobilize the right lobe of the thymus gland and wrap the thymic fat between the artery and airway.

## Postoperative Care

Right upper-lobe sleeve resections generally do not have a problematic postoperative pleural space. Similar to conventional right-upper lobectomies, sleeve resections rarely require a pleural tent or local anesthetic injection of the phrenic nerve to manage the residual pleural space. We routinely place two 28F chest tubes in the operating room. The chest tubes are typically removed within 2 days of surgery. Chest radiographs are obtained daily until discharge. Most right upper-sleeve lobectomies are discharged within 5 days of surgery. Chest radiographs are obtained 10 days and 6 weeks after discharge. Surveillance bronchoscopy is typically performed at the second postoperative visit to confirm normal healing.

## Comments

Bronchial sleeve resection of the right upper lobe is the most common bronchoplastic procedure. The procedure should be considered in any patient with a proximal right upper-lobe tumor. Staging of the patient should include a bronchoscopic evaluation of the potential resection margin. Potential nodal metastases need to be carefully evaluated by cervical mediastinoscopy. At the time of thoracotomy, additional nodal sampling is required to assess the feasibility of sleeve resection. The surgeon who methodically evaluates each patient for possible sleeve resection will often be rewarded with an operation that produces an acceptable oncological result while preserving lung tissue and improving the quality of their patients' postoperative survival.

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